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# IE PHYSIOLOGIC UNIT.

BY

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The complex problem of physiology must be solved by a generalization embracing electric, chemic and physical laws. Hence, in order to render plain certain principles which are the bases of physiologic action, the following postulates are formulated:†

1. That ether is the simplest form of matter; that it is molecular, and that it has a chemistry. (Fig. 1, A.)

2. That electricity is the chemistry of ether, *i. e.*, that dissociation and association of ether atoms or units constitute electricity in the broadest sense of the term. (Fig. 1, B.)

3. That electric potential and chemic potential are fundamentally identical being based on the potential of free ether-units or atoms; differentiating, in as much as in the former the ether-units are completely free, and in the latter they are constituents of and are partially neutralized within the chemic atom. (Fig. 1, B, C.)

4. It follows that there is an analogy between electric manifestations and molecular conditions, and that a study of the one will enable us to define the other. (Fig. 1, D, E.) Consequently the following definition of a molecule must be accepted: That it is the physical unit; that its ultimate constituent units are identical with ether-atoms; that it has a potential of unneutralized units of positive or negative quality; that this potential is represented in an induced magnetic field surrounding the molecular body, and therefore may be termed the *inductive potential*; that this tri-dimensional induced field is the molecular free or vibratory space; and that there are no free spaces within the ponderable body of the molecule, the units being in direct contact and more or less immolecularly neutralized. (Fig. 1, C, E.)

* The writer intended to read this paper at the meeting of the National Medical Association, held at Saratoga Springs, June 10 to 13, 1902, but the programmes were closed before the title was presented.

† In a paper read before the California State Medical Society, April, 1902, these postulates have been more fully explained.

5. That chemic atoms are groups of ether-units; that they associate and disassociate in obedience to their quantitatively and qualitatively differentiated potentials represented by the extrinsic neutralization of their units; that within the molecule they are more or less neutralized through direct contact with other chemic units, and they therefore have no free surrounding spaces, and consequently lose their identity within the molecular construction.

6. That atomic and molecular states are mutually transformable: At a specific decrement of pressure an atom dissociates and assumes the molecular condition; and at a specific increase of pressure a molecule will unite with another molecule although qualitatively the same in potential, the constituents of the nascent molecule having a common induced field; that dissociation is progressive until ultimate ponderable units are reached, and in general is according to a fixed law. The dimensions of molecules decrease, and their potentials and induced areas increase in inverse proportion to pressure, and in direct proportion to temperature.

7. That crystallization is the great physical analogue of physiologic action (Fig. 1, G, I), having the following factors: Molecular polarization; equipotential hemispheres of the molecule when polarized; association of other molecules in order that the hemispheres should be equipotential—absorbing water of crystallization; and the dissociation of these additional molecules—dehydration—on molecular depolarization.

8. That the physiologic unit is molecular in character having an inductive potential of negative quality, and surrounded by a tri-dimensional induced magnetic field in which are polarized ponderable molecules (Fig. 1, H); that it has the property of differentiating its poles—polarization—(Fig. 1, I) and associating additional molecules in order that its hemispheres be equipotential, and dissociating these molecules on depolarization.

9. That the molecular conception of the physiologic unit leads us to formulate the following law: That the physiologic unit at rest is in the electric state, with a uniform induced magnetic field (Fig. 1, H); and that in action it is in the magnetic state, with differentiated poles

and differentiated induced magnetic polar fields. (Fig. 1, I.)

10. That the potential of a molecule or cell must be estimated on the basis of constituent ether-units, and not on that of chemical atoms. Thus, water having 16 parts of negative oxygen, and 2 parts of positive hydrogen is apparently electro-negative, but a proximate estimation of ether-units in the atoms of oxygen and hydrogen shows water to be electro-positive, and this accords with the physical character of water and its behavior under electric currents.

11. That at the moment of depolarization, there are dissociated at the poles of the physiologic unit an extreme positive and an extreme negative atom—ions—the course of which differentiates; and that the dissociation constitutes the waste of the unit. (Fig. 1, K.)

12. That the nutritive element of the physiologic unit must be identical with its waste elements, although differing in potential; and that the unit receives molecular nutrition qualitatively the same in potential as its own, and hence the union must be accomplished by extrinsic pressure. Hence the formula: The unit during rest associates molecules as nutrition, and during action dissociates them as ions.

13. That fundamentally physiologic units are identical, only quantitatively differing in potential; and that functional differentiation is accomplished by the differentiation of environment.

14. That ions produced by gland-cell action are impressed into blood elements, and build up the latter in potential, which become *potential carriers*, returning to the circulation through lymph channels (as in the thyroid), or forming the principle constituents of an internal secretion (enzymes, etc).

15. That the product of reactions between lymph-salts and ions produced by cell-action furnish *secondary ions* which constitute the essential nutrition for cell-division, as shown by segmentation of spermatogenetic cells. That these secondary ions may be produced in any part of the body through circulatory and osmotic changes, hence any physiologic cell may assume reproductive properties and become pathologic, as in the growth of tumors.

In figure 1 the symbols + and — represent units of matter and units of force, quantitatively equal but qualitatively opposed; A, represents a molecule of ether, in which the units are immolecularly neutralized, hence it is potentially at zero; B, the positive and negative units separated, and the signs respectively represent positive and negative

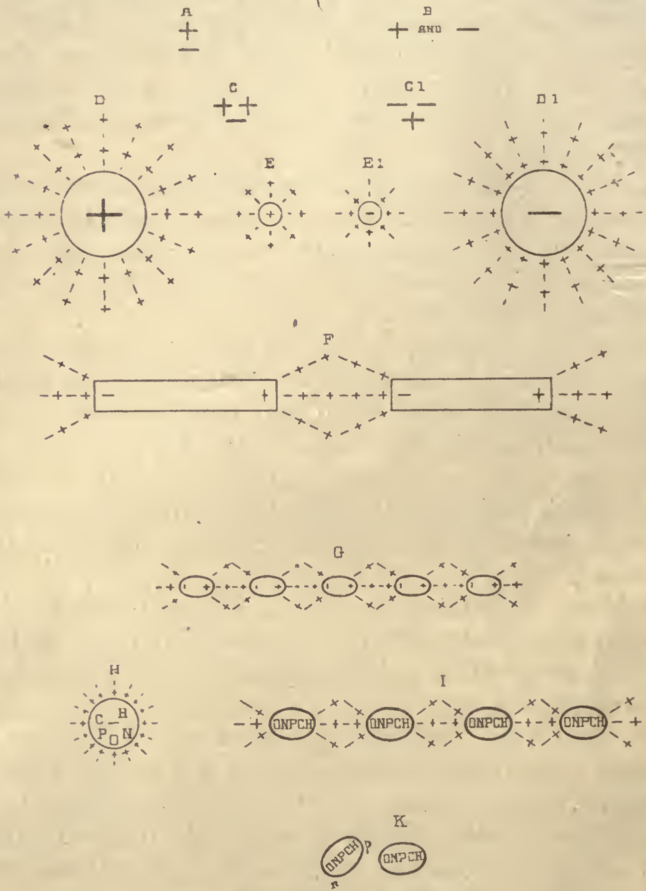


Fig. 1.—Potential differentations.

electrifications; C, positive and negative primary molecules of ponderable matter, each being equal in potential to a free unit of ether, or a unit of electricity. In the vacuum tube similar molecules have been demonstrated by Professor Thomson to be carriers of electricity, and to be one thousand time smaller than the hydrogen atom; D[1], D, positively electrified bodies with uniform induced magnetic fields, the induction being demonstrable by placing a con-

ductor within the field; E, E$^1$, molecules of ponderable matter, surrounded by tridimensional induced fields or free vibratory spaces; F, magnets with differentiated polar induced fields, also demonstrable; G, molecules of a magnet with differentiated polar induced fields; H, the physiologic unit at rest, potentially of negative quality, and surrounded by a uniform induced field; I, the physiologic unit polarized or in action, with differentiated poles and differentiated induced fields—they are in a state of tetany, coagulation, crystallization, etc.; K, a physiologic molecule depolarizing, with p and n representing ions dissociated at their respective poles. Specifically, the p represents hydrogen and carbon, and n represents oxygen, respectively the most positive and negative chemic constituents of the physiologic molecule.

*Molecular Potential, Molecular Induced Field, and Molecular Polarization.*—These principles are universal properties of ponderable matter, and upon these the manifestations of the inherent forces of matter, as expressed through natural phenomena, are based. The writer believes that physiologic phenomena do not form an exception to this rule.

*Molecular Potential* depends upon the absolute number of the constituent ether-units of the molecule; upon their relative number as to positive or negative quality; and upon their relative placement within the molecule. Molecular potential differentiates according to the neutralizing force—a gravitating potential when the neutralizing force pertains to a mass such as that of the earth; a chemical potential when the neutralizing force is the polar potential of an adjoining molecule; and other differentiations may be made according to the force opposed. The *inductive potential* of a molecule may be defined as the difference between the sum of its positive and the sum of its negative constituent ether-units, and this potential is represented by induction in the surrounding magnetic field of the molecule. (Fig. 1, D, E, F, G, H, I.) It is evident that the inductive potential may be of positive or negative quality. This potential is a most important principle in the production of physiologic phenomena.

*Molecular Induced Magnetic Field.*—This tridimensional space, when not distorted by external pressure, uniformly

surrounds the molecule: it is directly dimensionally proportional to the inductive potential; and it is the free or vibratory space of the molecule. In the induced fields of small molecules ether is polarized, this being the only form of matter so molecularly minute as to occupy intermolecular spaces; in the induced fields of electrically charged bodies and in those of physiologic molecules ponderable matter is polarized.

*Molecular Polarization.*—By this is meant that all the molecular poles of a kind point in one direction. (Fig. 1, F, G, I.) When a molecule polarizes it assumes the spherical form with *equipotential hemispheres.* If the relative number of the molecular constituent positivities and negativities prohibit the hemispheres from becoming equipotential on polarizing, the molecule either imbibes additional molecules, as in the case of crystallization, etc., or it extrudes molecules, as in the case of segmentation. The former we have termed *associating molecules* and the latter *dissociating molecules of polarization.* The associating molecules when given off may be termed *dissociating molecules of depolarization.* It is evident that a body having its molecules polarized will itself have poles; and that if such a body be a unit of a larger body the latter will also have poles. The molecules, unit bodies and the larger body will have poles uniformly directed. (Fig. 1, G, I.)

*The Physiologic Unit.*—It may be practically impossible to ascertain the exact chemistry of the physiologic unit. However, it may be assumed that it is composed of hydrogen, carbon, phosphorus, nitrogen and oxygen. Sulphur is probably an element of the protecting or insulating tissues. The unit may contain thousands of chemic atoms, and the constituent ether-units may be numbered by trillions. All electro-neuro-muscular facts point to the unit having a *negative potential.* As it becomes exhausted it approaches neutrality, and probably has a base which is potentially positive. The base must have a permanent character, that is, it is not altered by functional activity, as a complete disintegration would imply a temporary loss of function of the organ of which it is the structural unit. The acid reaction obtained in nerve and muscle, after a period of functional activity, points to the elements of waste, being, in the gross, *electro-negative* in quality.

As the physiologic unit takes on certain elements as nutrition, with a gain of potential, and gives them off as waste, with a loss of potential, and as there has been work done, the inherent potential of the waste elements must be greater than that of the nutritive elements. The work done by the unit must be equal to the difference of potential between the nutritive and the waste elements. The metabolic changes involved must be molecular, and must be accomplished by a molecule. No other conclusion can be arrived at. This subject is specifically discussed under section on waste and nutrition.

*Mass and Molecule.*—A mass is composed of molecules. As the potential of each molecule is represented in its own induced field, it follows that a mass can have no induced field, except under such pressure as will distort the induced fields of the molecules. Conversely, if a body has an induced field it must be molecular in character, except it is electrically charged, a condition impossible in a body surrounded by electric conductors.

*Nucleolus.*—Wherein resides the potential by which functional activities are accomplished? Our answer is that the potential is in the nucleoli of cells, in the anisotropic substance of muscles, and in an analogous unit in the axis cylinder of nerves or in the cytoplasm of their cells, and that these bodies are molecules of high negative potential, having the property of polarization, the fundamental principle of all function; and that they are surrounded by induced magnetic fields—the nuclei of cells, the isotropic substance of muscles, etc.; that when they polarize they associate molecules of polarization, and dissociate these molecules on depolarization (Fig. 1, H, I); and that function is accompanied by the splitting up of molecules into ions.

The optical properties of nucleoli are not inconsistent with a molecular character. Their highly refractive powers may be owing to their diameters being much greater than the length of light-waves. The anisotropic property of the muscle-disc, the light and dark bands, the difference shown by the resting and contracting fiber when examined by high power, may be in the line of further investigations, which may furnish demonstrable proof that the anisotropic substance is molecular, and the isotropic substance its in-

duced field; the latter having innumerable polarizable bodies which are also molecular in character. The conception of the chromosomes of the nuclear field being molecules, which are built up to a negative potential by the ions produced by the nucleolus, will explain how these bodies move towards the cytoplasm by a reciprocal repulsion of similar potentials, which exist between them and the nucleolus.

The nuclear elements, therefore, may consist of material of negative potential moving from the nucleolus, and other material of positive potential moving toward that body. The latter is probably composed of the basic material of cells, perhaps nuclein, and nutritive elements, such as the proteids and hydro-carbons. The former may be composed of nuclein built up to a negative potential, and some katabolites resulting from the metabolism of nutrition. Amongst the katabolites, however, there must be a certain desideratum of potential of positive quality, which is not repelled by the negative nucleolus. Carbon and hydrogen must enter largely into this element, although there may be secondary reactions between these and blood-elements. This by-product may be disposed of by extrinsic pressure and osmotic action, but herein may rest the principle on which the cell ages.

When certain elements of the nucleus leave the area of induction and are free to act on their own polar potentials, they mutually attract and form a membrane which envelops the nucleus. In the division of the cell, when there are two centrosomes—nucleoli—the membrane again comes within the induced sphere, and the elements are polarized by primary potentials, and the membrane disappears, to again appear when division is complete.

*Associating Molecules of Polarization.*—Crystallization of certain salts, coagulation of the blood, rigor mortis, contractility, conductivity, and, it may be presumed, the functions of all cells, and various other physical and physiologic phenomena, have, as an essential factor, association of molecules of polarization. A principle so wide in its application must differentiate in detail, and we find that the associating molecules vary according to the potentials of the polarizing bodies; thus, certain salts demand from one to many molecules of water in order to crystalize, whilst

there is alcohol, benzine, and molecules of other substances essential to other crystallizing bodies. A calcium salt is necessary for the coagulation of the blood. Sodium and other salts stimulate the action of nerves, whilst most potassium compounds interfere with their function.* Muscular contraction takes place only in the presence of certain salts, and these may differ in striped and unstriped muscular fibers. An ovum will functionate only when associated with a definite compound with a distinctive potential commensurate with the deficiency of its positive pole or corresponding hemisphere. The sperm centrosome is such a compound, but here, again, the ovum and sperm may potentially differentiate in individuals, in races, and in species, so that each unit has its co-efficient, the joint efficacy being limited to certain spheres of differentation.

Obviously, all molecules polarize with equipotential hemispheres, and with poles qualitatively differentiated but quantitatively equal; the inductive potential of the polarizing molecule must be equal in quantity but different in quality from the potential of the co-efficient; and the great principle of polarization must underlie physiological as well as physical phenomena, being the main factor in the crystallization of a salt and the fecundation of an ovum. When a molecule depolarizes, dissociation of the molecules of polarzation takes place. In crystallization this has been termed dehydration. The writer suggests, as a general term, *dis-association of molecules of polarization.* It is worthy of observation that these additional elements of polarization are associated as molecules, and are evidently dissociated in the molecular state, no change in their physical or chemical character having taken place.

*Fundamental Principle of Function.*—It is evident that there must be an underlying principle to all functions. As all structures are built up from the same histologic unit, so the differentiated functions must have a common principle. That principle is *polarization*, and the differentations belong to environing conditions. Under distinctive and exact conditions of pressure and temperature, amidst ions produced by already formed structures, the unit is built up to a high potential of negative quality. (Fig. 1, H.) Placed in position where, by means of extrinsic pressure, molecular

* Dr. A. P. Mathews, *Century*, March, 1902.

nutriment is forced into its construction, and bathed by a solution containing the distinctively differentiated and essential molecules of polarization, the physiologic unit, under proper surroundings, with the proper initiatory stimulus, is ready to perform all functions.

*Waste of Unit-Action.*—The physiologic unit is probably represented by the following formula: — O N P C H +, the atoms, being placed in the order of their electro-negative and electro-positive character. When polarized, the most electro-negative atoms will constitute the negative pole, and the most electro-positive will constitute the positive of the unit. During polarization these elements are held fast at their respective poles. Now, the hydrogen atom at the positive pole is attracted towards the equator of its own molecule and towards the negative pole of the adjoining molecule, according to the great law that forces react in inverse proportion to the square of the distance asunder. (Fig. 1, I.) Clearly, the hydrogen atom will tend to leave its molecular situation and dissociate at the moment of depolarization. The same may be said of its fellow, the carbon atom, although its attractions are less positive. The oxygen atom at the opposing pole will also dissociate for the same reasons. Hence, there are hydrogen, carbon, and oxygen in the nascent state as a result of each vibration or polarization of the physiologic unit, and hence these constitute the waste elements; and it follows that the increased potential of the nascent elements represents the amount of work done by the polarizing act. Their potentials also represent the amount of energy spent when a molecule of nutrition of negative quality is impressed into the physiologic unit also of negative quality, by extrinsic pressure.

The transformation of energy may be stated thus: Work done by extrinsic pressure increases the potential of the unit by adding a molecule to the unit, the potential of the physiologic unit and the nutritive molecule being of negative quality. The increased potential of the unit may be termed a *potential of concentrativeness*. It is similar to the potential of a gas gained by compression. The potential of pressure is converted into a potential of concentrativeness, and takes place during the rest of the cell or unit. When the unit polarizes, the potential of concentrativeness

is transformed into a *potential of diffusibility*, as represented in the ions separated from their respective poles. The three potentials, extrinsic pressure, concentrativeness, and diffusibility, must be quantitatively equal. Thus within the body energy merely has been transformed; outside the body if work has been done such as lifting a weight to a higher level by means of muscular contraction, the weight gains a potential by being placed further from the center of gravity, but a column of air has approached that center and accordingly loses potential. The balances are complete, within and without. The transformation of energy traced further shows differentiation. In muscle and nerve the ions combine and form simple compounds, the energy diffusing as heat. In the glands the ions perform an important anabolic function. These have been considered in a separate article. The transformation taking place in the nutritive process in the neurone will be considered here. The definition of ions may be stated thus: *Ions are dissociated constituents (chemic atoms) of a molecule, which have assumed the molecular condition with subnormal dimensions and supernormal potentials according to the standard of environment.*

*The Neurone.*—The neurone is a distinct morphologic body and consists of its cell, protoplasmic and axis cylinder processes, end arborizations and collaterals. It is analagous to an electric body, made up of a number of parts, all of them conductors, surrounded by an insulatory medium. On looking for an electric body with which to compare the neurone, the author selected the conductor—comb, fork, conducting wire and electrode—of a static machine. (Fig. 2 ) This body is excited at the comb, manifestations appear at the electrodes, and it is insulated by non-conducting material, and so far resembles the neurone. There is no doubt the neurone is physiologically insulated, but owing to its special form of conduction it is not necessary that the insulation be electric in character. The myelin sheath may be an insulator of nerve force, and at the same time be an electric conductor. It is the insulation of a magnet rather than that of an electric conductor.

There can be no doubt of the identity of nerve and electric force when brought to an ultimate analysis. But a neurone performs functions which an electric conductor

does not; and it manifests phenomena which metallic conductors, as the best conductors, are incapable of manifesting. It is obvious that in order to produce electric phenomena in the metallic conductor an external force is required proportioned exactly to the work to be done through the conductor, and to the electric potential located in it.

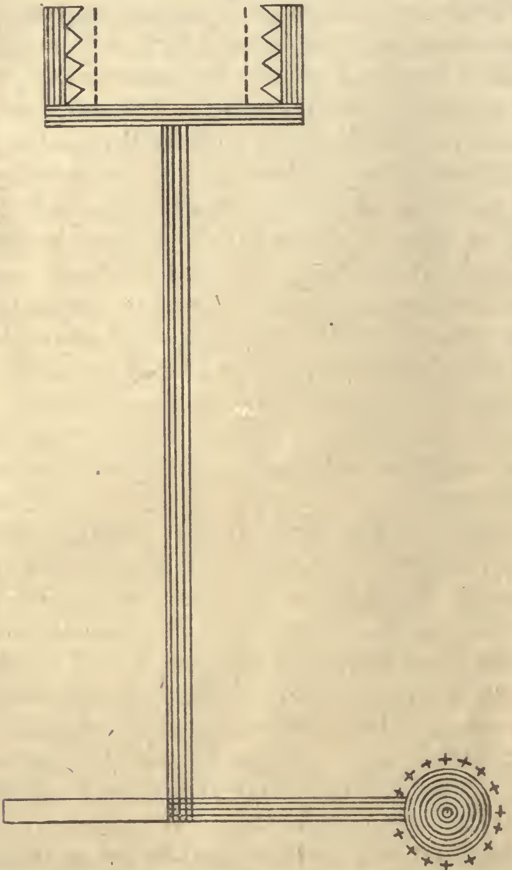

FIG. 2.—Electric conductor, the analogue of the neurone.

With the neurone it is different, a slight touch on a nerve terminal, an indistinct sound, or a faint ray of light is sufficient to excite a nerve terminal; and these forms of excitation in dynamic force are not to be compared with the resulting energy liberated or work done. Hence we infer that a nerve conductor has a supply of energy or potential not possessed by a simple conductor; and hence we arrive at the conclusion that the fundamental difference between a nerve and an electric conductor lies in the potential of

molecules; and that the difference in the potential of molecules (organic and inorganic), is one of degree and not of kind. Obviously the potential of a nerve conducting molecule is immensely greater than any ordinary electric conducting molecule, possessing, as the former does, the two factors: (1) great number of atoms, and (2) these preponderately inclined in one direction, the negative.

For the accomplishment of nerve action a high potential molecule is the first essential. Molecular polarization is the first step in electrical conduction, and this is equally true in nerve conduction. The molecules of the neurone must be set therefore in symmetric order, and capable of moving freely within their free paths or vibratory spaces. The conducting structure must be homogenous, or at least the physiologic molecules must be capable of being timed as to vibratory pace, so as to conform to the rhythm of the specific physiologic excitant. There is then in the neural ultimate conducting fibril a line of physiologic molecular units of uniform character and having uniform interspaces (Fig. 1, H, I), the latter constitute the induced fields and are entirely dimensionally regulated by the negative potential of the units.

*Nutrition of the Neurone.*—When certain complex molecules of living matter polarize, as during nerve conduction, some of the atoms separate from the main bodies of the molecules or units. We have shown, and physiologic facts support us, that the dissociated atoms are oxygen, carbon and hydrogen. If these are the elements of waste, they in some form must be the elements of nutrition.

When an insulated electric conductor is electrified its surface is *equipotential:* That is all parts of the conductor shows electrification in an equal degree. When a liquid is poured into a vessel the surface of the liquid becomes a plane. If more liquid be added its surface will still be level. *Here we have a physically equipotential surface.* A line of molecules of high potential, finely adjusted and insulated will tend to be *chemically equipotential.*

In the Daniell cell a *displacement-movement* takes place in order to establish a chemically equipotential surface as shown in the following formula:

$$Zn \begin{matrix} Zn & Zn & Zn & Zn \\ SO_4 & SO_4 & SO_4 & SO_4 \end{matrix} \Bigg| \begin{matrix} Cu & Cu & Cu & Cu \\ SO_4 & SO_4 & SO_4 & SO \end{matrix} \; Cu$$

Zn represents the zinc plate; $ZnSO_4$ represents a solution of zinc sulphate; Cu SO represents a solution of copper sulphate. These solutions are divided by a porous partition. Cu represents the copper plate. The explanation of the formula is as follows: The zinc atom is more positive than the copper atom, consequently the negative radical $SO_4$ has a tendency to leave the copper atom and unite with the zinc thus setting free energy. The difference of potential is not sufficient to cause chemic reaction unless a way is provided for the energy to escape with slight resistance. The conducting circuit provides the necessary path. Under these conditions there is a general movement of the radicals $SO_4$, by displacement, toward, and to unite with the zinc, whilst copper is deposited on the copper plate.

The axon of the neurone body in some instances terminates in a hillock within the cell, and in other instances is continued through the cell. Within the cell is a mass of protoplasm and hydrocarbons. This mass is composed of molecules of high potential, and therefore will readily dissociate when the means of escape is provided for the energy. There is, however, in this protoplasmic mass a certain amount of pressure exerted constantly, just as there is in the Daniell cell. This pressure has two factors: (1) The chemically high potential of the molecules of the material, and (2) the osmotic pressure of the blood supply.

After a period of rest there is established between the molecules of the conducting fibrils and the protoplasmic material a chemic equilibrium. During nerve action the conducting molecules lose part of their oxygen, carbon, and hydrogen, which lowers the molecular potential of the fibrils and disturbs the equilibrium. This lessens the resistance to the pressure within the cell, and provides a way for the escape of energy. There immediately ensues a breaking up of the molecules of high potential of the protoplasm and hydrocarbons within the cell, and the simpler compounds escape by different routes. The re-establishment of the equilibrium between the nerve fibril and the cell is accomplished by a *displacement-movement of hydrogen carbonate along the fibril.* By an anabolic process the potential of the physiologic units, or molecules, of the fibrils is regained at the expense of contemporary kata-

bolism in the cells. (Fig. 3.) It must be borne in mind that there can be no attraction between the physiologic unit and the molecules of nutrition—$H_2CO_3$—as both are negative in potential, therefore the potential gained by the units of the conducting fibre is equal to the extrinsic pressure derived from the katabolism of the cell. Hence, the steps in the transformation of energy, accomplished by the functionating act of a physiologic unit, may be formulated thus: The unit takes on molecules of nutrition, $H_2CO_3$, and splits them into ions—hydrogen, carbon, and oxygen. It

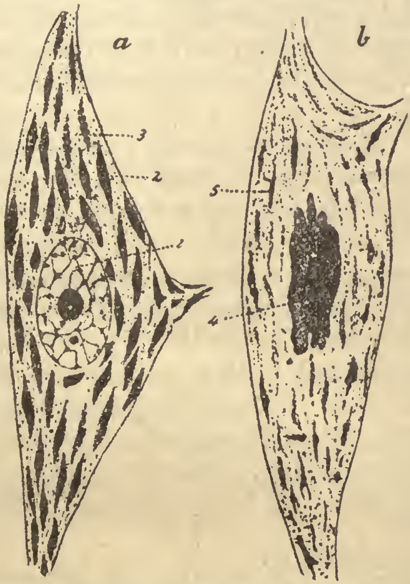


FIG. 3.—Two motor cells from lumbar region of spinal cord of dog fixed in sublimate and stained in toluidin blue. *a*, from the fresh dog: 1, pale nucleus; 2, dark Nissl spindles; 3, bundles of nerve fibrils. *b*, from the fatigued dog: 4, dark shriveled nucleus; 5, pale spindles. (After Mann ) (From Barker.)

will be seen that the cell is a store-house of energy, and that it is capable of supplying nutrition for some distance from its site; but only to maintain the potential of a unit whose base or foundation has already been laid. When new cells are needed, as when the structural continuity of the neurone is broken, a more direct blood connection is demanded. Thus, the neurone is repaired from the pheriphery. It is obvious that a collection of units not strictly belonging to the nerve structure, but connected anatomically with nerve filaments, may receive nutrition through these filaments. From a study of the Graafian vesicle, the

author believes that this anomaly exists in the membrana granulosa.

*Reflex Action.*—In an article already published, the initiatory stimulation of the neurone and the propagation of the neural wave have been considered. Here, it may be stated that the leading-off point is always negative, and that the induced polar field of one molecule is a stimulus to the adjoining, just as the polarization in an induced field of a magnet causes polarization of a conductor within its area. It is clear that each physiologic unit within the neurone is stimulated by a positive excitant—the positive polar potential of the preceding unit—and it is obvious that the natural external stimulus to the initiatory molecule is also positive in character.

How does the distal terminal of one neurone stimulate the proximate terminal of another? To understand the principle on which this phenomenon is based, and the variations in intensity which it undergoes, a study of dielectric constants, or specific inductive capacity, of dielectric media is necessary. By specific inductive capacity is meant that quality possessed by media of modifying the potential between two charged bodies, the charges on the bodies remaining the same. Thus, with air as unity, the following table gives the inductive capacity or dielectric constants of the substances named:

| Substance. | Dielectric Constant. |
|---|---|
| Sulphur. | 2.58 |
| Carbon disulphide. | 1.81 |
| Hydrogen. | 0.999 |
| Carbon dioxide. | 1.0008 |

If there is a given charge on two bodies at a given distance apart, and sulphur is the dielectric medium, there will be a certain difference of potential between the charged bodies. This difference of potential will be increased immensely by substituting carbon dioxide or hydrogen for the sulphur. The substitution is equal to multiplying the charge by about two and one-half.

The organic substance neuro-keratin is found in the brain and in the medullary sheaths of nerve fibers. It contains a large proportion of sulphur and is probably possessed of insulatory properties. Sulphur, then, has very large specific inductive capacity, and is one of the constitu-

ents of neuro-keratin, a substance found in the medullary sheaths, a structure placed in a relative position to the axis cylinder to enable it to insulate the latter.

The last physiologic unit at the distal terminal of a nerve fiber, when polarized, has a free magnetic end insulated by neuro-keratin, from the initiatory unit of proximate dendrones of adjoining fibers, a condition analogous to that of a Leyden jar. The neuro-keratin is a shield, such as the copper cylinder introduced between the core and the primary circuit of some faradic batteries. Reflex action taking place between neurones is similar to electric induction and it demands similar conditions. The conception that nerve action taking place between two neurones is similar to induction, and that sulphur is the dielectric medium, is supported by the following facts:

1. In dyspnoa, where there is an accumulation of carbon dioxide, there is an increased elimination of sulphur in the urine.

2. Asphyxia of animals produced by placing them in a closed chamber and depriving them of air is accompanied by convulsions.

3. Exhaustion of nerve centers by continued action favors hysteria and allied affections.

4. The part of the nerve structure that is first influenced by encroaching disease is the myelin sheath, and this is the first part to degenerate when the nerve trunk is severed.

We find, therefore, that myelin is a very sensitive substance, and is the first to suffer when any departure from physiologic conditions takes place; we also find that carbon dioxide, when accumulated beyond the physiologic amount displaces sulphur, spasms ensuing; and that spasmodic action is favored by nerve exhaustion. The explanation of these facts seems clear: The sulphur is held loosely in the neuro-keratin and is displaced by an excess of carbon dioxide, whether taking place from excessive nerve action or accumulating otherwise; the sulphur being displaced, the inductive capacity of the insulating substance is immensely lessened, the difference of potential between the adjoining terminals of neurones is greatly raised, reflex action is increased and spasmodic action of various forms result. This conception of the insulation of neurones fur-

nishes a bases whereby the pathologic conditions underlying hysteria, epilepsy, and other spasmodic diseases are rendered clear.

*Molecular Segmentation.*—According to the law of Avogadro, equal volumes of all substances in the gaseous state under like conditions of pressure and temperature, contain the same number of molecules. This means that the tridimensional space, occupied by any ponderable molecule and its induced field (Fig. 1, E), is equal in area to those spaces of other molecules of gaseous substances under like conditions. It follows that as ponderable molecules of gases are of different sizes, and as their induced fields vary directly with their potentials, *that the potentials and induced fields vary inversely as the dimensions of the ponderable molecule.* It is by this law that the molecular equilibrium, as shown by Avogadro's law, is maintained. The molecules of the residual gas in a vacuum tube divide and subdivide in order to maintain this equilibrium. The molecules of a gas may be compressed until the solid state is reached—the induced fields are encroached upon by means of pressure until the ponderable bodies are in contact. It is obvious that potential and pressure are important factors in determining molecular conditions; and it is obvious that a ponderable molecule may be built up or torn down by the addition or subtraction of constituent elements.

If a physiologic unit or molecule be placed under certain degrees of pressure and temperature, and amidst ions, such as hydrogen, carbon and oxygen, set free by nerve action, it is evident that these will adhere to the surface of the unit, and the latter will accordingly increase in ponderable dimensions. Here, we will formulate the following law: *A physiologic unit is built up by ions furnished by other cells, but for the accomplishment of segmentation it is essential that lymph or blood-elements be present also.* A study of the differentional structure of the ovaries and testicles will show that this is the reason why there is only one ovum in the Graafian vesicle, and numerous spermatozoa in the testicular tubule.

All glandular structures must have poles just as the ends of a muscle have differential polarity. The glandular polar arrangement will determine the character of osmotic action

—of the alkalinity or acidity of the secretion. A physiologic unit, placed at the positive pole of an epithelial cell, in the midst of ions produced by nerve or gland-cell action, and bathed with lymph-salts, will be surrounded by all the elements which its constituency demands for segmentation. The reaction taking place between the carbon and oxygen ions on the one hand, and the bases of the salts of the lymph on the other, will set free compounds of phosphorus and nitrogen, which, with ions not reacted on by the bases, will form the essential nutritive elements for cell reproduction. The physiologic molecule may be built up until its centrifugal and centripetal forces are equal, and this equilibrium will depend on the degree of extrinsic pressure. When local attraction at the circumference is greater than the sum of opposing forces—attraction towards the center, and the extrinsic pressure—it is evident that a new center will be formed which will dispute possession of the intrinsic forces of the molecule.

Now, in such a condition, when the molecule polarizes with equipotential hemispheres, it is evident that there will be shut off a certain portion, *i. e.*, instead of associating molecules of polarization, the polarizing unit will dissociate molecules of polarization—certain molecules will be extruded from the spherical area in order that the hemispheres be equipotential. When the building up process has reached an extent, so that the repulsion between the extruded portion and the body of the unit (both being of negative potential) is sufficient to overcome the resistance of external pressure, complete segmentation will take place. Segmentation of the primary potential of the physiologic unit or nucleolus will be accompanied by division of the induced magnetic field or nucleus. The collective phenomena, termed karyokinesis, may be illustrated by the division of a negatively electrified body. (Fig. 1, D, E.)

*Classification of Cells According to Nutrition.*—Nutrition is essential to the functional activity of all cells. It is obvious that in order that a cell-molecule shall gain in potential-energy the nutritional elements must be qualitatively the same in potential as the cell. It has been shown that the activity of most cells is accompanied by conversion of molecules into ions. This rule does not apply to all cells. It is evident that a cell which reproduces itself requires

different nutrition from a cell which functionates and gives off a limited number of its constituent elements as waste.

This leads to a conception of a classification of cells on the basis of the character of their nutrition. The classification is formulated as follows:

1. Cells that are surrounded by elements such as proteids, hydrocarbons, etc., which, by katabolism, furnish molecules of nutrition, which are converted by the functionating cell into ions. Specifically, the molecules of nutrition are hydrogen carbonate, and the ions hydrogen, carbon and oxygen. Such cells do not multiply but retain a stable base. They are the cell-molecules of muscles, nerves, glands, electric organs and most nucleoli.

2. Cells that are placed in the midst of ions produced by other cells; are built up to a high negative potential, are shut off from blood or lymph-elements, and are incapable of segmentation, and perform no function under their primary environment. The ova are such cells.

3. Cells that are acted upon by ions, and by secondary ions produced by reactions between the primary ions and the lymph elements and which have the property of reproduction. To this class belong the spermatogenetic cells, and probably embryonic cells, and cells of tumors.

4. Blood-cells which pass under the influence of, and are built up by ions furnished by other cells, and pass again into the circulation, into a secretion, or into cytoplasm. These are *potential-carriers*, enzymes, etc., of the secretions, and nuclear elements.

The classification might be extended, but the above is sufficient to show that cells, being histogentically related, may be transformed from one class to another by means of a change in the nutrition; and that the transformation may be physiologic or pathologic in character. Thus ova by differentiation of environment, and on being supplied by the essential associating molecules of polarization and nutritive elements acquire reproductive properties; and from the resulting segmenting cells permanent cells of the tissues are planted. Again a simple permanent cell of the serous covering of the ovary is converted into an ovum. The physiologic processes by which these transformations are accomplished are not by changing the fundamental character of the cell but by a change or changes in its envi-

ronment and nutritional elements. Furthermore, this rule holds good when the transformation is from a state which is physiologic to one which is pathologic.

The anatomical differentation as seen in the testicle is a type of essential conditions of cells that have the property of reproduction; and the osmosis in this structure is such that the lymph salts are acted upon by ions, and the product bathes the segmenting cells. The anatomical arrangement shows that osmosis takes place from the lymph spaces to the tubuli seminiferi. Spermatozoa taken directly from the testis are quiescent. This is evidently owing to the electro-negative character of the secretion. It is obvious that circulatory pressure must direct osmosis from the lymph spaces toward the tubuli, but the polar differentation of the endothelial cells bounding the lymph spaces determines the quality of the osmotic flow.

The following changes are submitted as factors in the causality of the growth of tumors: (1) Continued circulatory modifications, which weaken sensitive anatomical elements, such as myelin sheaths, elastic fibres, etc. (2) Retardation or blocking of lymphatic streams. (3) Change in the osmotic flow, so that the conditions approach those of the testicular glands, a change qualitatively determined by the polarity of tissues.

Granting that the general formula of the cell-molecule or nucleolus is: $-$ ONPCH $+$, it is evident that if it is fed with oxygen, carbon and hydrogen, it may be built up to a high negative potential, as in the case of the ovum, or it may functionate, as in the case of a nerve or muscle cell, but it is equally evident that it cannot reproduce from such nutritional elements, except at the expense of its stability as a cell. If it is fed with compounds of oxygen, nitrogen, phosphorous, carbon and hydrogen, under the essential conditions it may reproduce a cell similar to itself. Furthermore, if to these elements are added a positive element, such as calcium or sodium, it is obvious that reproduction may take place with a change in the character of the cell. It is also obvious that if division take place a number of times and the cell fed with the positive element, that its quality may be entirely changed from a negative cell to a positive one. This is exactly what must take place in the metabolic changes that convert the spermatogonia, evi-

dently negative, into cells with electro-positive nucleoli and having fecundating properties. Beginning with two cell-molecules, qualitatively identical, nature feeds one with a few elements, in the main negative, and constructs an ovum, and feeds the other with elements, in the main, of a positive quality, and converts it into a sperm nucleolus; and the relationship of the two is as that of water of crystallization and crystallizing salt. The one is co-efficient to the other.